the medical standpoint, and the portion of the report for which he is responsible is clear, concise, and intensely practical. Dr. Cunningham's report contains a full account of phosphorus necrosis, and is illustrated by diagrams showing various stages of the disease in the teeth and jaws. This condition is the most frequent and most obvious of the poisonous effects of phosphorus; it is not by any means the only one. He also gives in full the precautions which should be adopted in all factories for combating the injurious effects of the poisonous fumes. There are various appendices which give in detail the facts upon which the main body of the report is founded.

The whole report is a clear evidence of the painstaking way in which the Commission has carried out of its work, and is specially valuable, seeing that the investigators have visited various foreign countries in order to compare what is being done there with what occurs in our own country. An admirable summary of conclusions is furnished by Dr. Arthur Whitelegge, the chief inspector of factories. The main conclusions are as follows:—

In the match industry two forms of phosphorus are used: *yellow phosphorus*, which is highly poisonous, and gives off poisonous fumes which consist mainly of low oxides of phosphorus; and *red phosphorus*, which does not fume, and is hardly poisonous even if swallowed.

Then, as is well known, there are two principal varieties of matches used: the "safety matches," which are tipped with a composition free from phosphorus; the surface on which they strike is covered with a composition of which red phosphorus forms a part. The "strike anywhere" matches are tipped with a paste containing yellow phosphorus in a proportion which varies from 3 to 30 per cent.; but in this country not more than 6 or 7 and often less than 5 per cent. is used. It is in the making of such matches only that danger arises. Attempts are being made to make "strike anywhere" matches which contain no yellow phosphorus, and rewards have been offered for an effective match of this kind, but up to the present these efforts have not been successful; either such matches do not strike anywhere, or else they are violently explosive.

The specially dangerous processes in the manufacture of matches containing yellow phosphorus are *mixing* the paste, *dipping* the wood or wax stems, *drying* the bundles after dipping, and *boxing* the dried matches; it is the last process which involves the most handling of the matches.

The rules that already exist require (1) natural and mechanical ventilation to be efficient in the rooms where these processes are being carried out; (2) effectual means to prevent the fumes entering other parts of the factory; (3) that no person shall be employed who has suffered from necrosis, or had a tooth extracted; (4) that persons suffering from toothache shall be at once medically examined; (5) notification of cases of necrosis is obligatory; and (6) proper conveniences for washing shall be provided.

Both here and abroad many firms have done a good deal more than this: the dental supervision has been efficient, and the introduction of elaborate machinery instead of hand labour in the four dangerous processes has done more than anything else to lessen the danger. In some foreign countries the precautions taken are in advance of our own, but in this country special praise is given to the Diamond Company's factory at Liverpool, where cases of phosphorus necrosis have never occurred. In Germany, Austria, and Switzerland, there is, however, the surreptitious manufacture of matches as a home industry to be contended with; this disastrous practice has, happily, not been attempted in Great Britain.

The main point which the Commission had to decide was undoubtedly whether they should recommend the use of yellow phosphorus to be prohibited. We may give their decision in their own words:—

"So far as the home consumption is concerned, it does not seem that the prohibition of the use of yellow phosphorus would involve any serious hardship, and this course has already been adopted by Denmark, and decided upon by Switzerland, care being taken at the same time to prohibit the use or importation of yellow phosphorus matches. But neither of these countries has or had any export trade to lose. The United Kingdom, Belgium, Sweden, and Japan, manufacture largely for export,[1] and it is feared that immediate prohibition of yellow phosphorus would at once divert that portion of our trade to other countries, unless international agreement upon the subject was arrived at. If grave injury to the health of the workpeople were inevitable, the loss of the trade might well be regarded as the smaller sacrifice of the two, but the result of the inquiry points to a different conclusion. With due selection of workpeople, strict medical and dental supervision, proper structural and administrative conditions, and substitution of machinery for hand labour, it seems that the dangers hitherto attending the use of yellow phosphorus can be overcome."

We need not go into the details of all the precautions set forth; they will involve revision of the present rules, and put briefly they consist of absolute cleanliness, perfect ventilation, medical selection of workpeople (children, debilitated persons, and those with unsound teeth being excluded), compulsory dentistry, substitution of machinery for direct handling, and limitation of the percentage of phosphorus in the paste.

We learn that in Russia a tax is imposed upon the manufacture of yellow phosphorus matches, with the result that safety matches are displacing the "strike anywhere" kind. The Commissioners make no recommendation that a similar tax should be imposed here; they are also silent in regard to recommendations concerning international agreement in view of the total prohibition of the use of yellow phosphorus. No doubt this would have been the most stringent and the most effective course to adopt. But legislation is a slowly moving machine, and international legislation a more cumbrous one still. Recognising this, the report suggests what is a more practical remedy, and certainly a more immediate one. What has been accomplished by the Diamond Factory at Liverpool should be made compulsory elsewhere, and for the sake of the workers it is to be hoped that there will be no delay in carrying the suggested rules into operation.

MIMICRY AND WARNING COLOURS.[2]

IT is just twenty years ago since the late Charles Darwin called the writer's attention to a little paper, by Fritz Müller, published in *Kosmos* for May 1879, and containing a new suggestion concerning the theory of mimicry. It was the writer's misfortune to have foreseen that the principle discovered by Müller was likely to exert a profound influence on certain biological problems of which the solution had up to that time been unattempted, and he accordingly introduced the new idea to the entomologists of this country by inserting a translation of the paper in the *Proceedings* of the Entomological

[1] For foreign and colonial use, especially in hot and humid climates, the yellow phosphorus matches keep better and resist damp.

[2] "Natural Selection the Cause of Mimetic Resemblance and Common Warning Colours." By Edward B. Poulton, M.A., F.R.S. (*Journ. Linn. Soc. Zoology*, vol. xxvi. pp. 558–612.)

Society of London. The misfortune lay in the circumstance that the entomologists of that time were unprepared for new ideas, and the writer had accordingly to incur the opprobrium of an innovator. He has happily survived this treatment, but how far any advancement has been made by entomologists since the year 1879 may be gathered from the discussion of the whole subject which was raised in the Entomological Society in 1897, and of which a summary is given by Prof. E. B. Poulton in the paper now under consideration. So far as the writer of this notice is concerned, the first gleam of encouragement came from Dr. Alfred Russel Wallace, who, with his well-known power of mental penetration, had no sooner had the case submitted to his judgment than he accepted the new doctrine, and incorporated it in his book on "Darwinism." From the discussion of 1897 it appears that the majority of our entomologists are still hostile to the Müllerian theory; but conspicuous among those who have helped to support and develop it is the author of the paper now before us. We may claim also Dr. F. A. Dixey, of Oxford; Mr. Roland Trimen, one of the early pioneers with Bates and Wallace in the subject of mimicry; Colonel Swinhoe; Dr. A. G. Mayer, of America; Mr. Gahan, of the British Museum, and some few others, as co-heretics in this later development of the theory of mimicry.

The original theory propounded by Bates in 1861 is so well known, and has been so frequently discussed in these columns, that it is unnecessary to restate it. The fundamental condition is that the imitated form should be objectionable to insectivorous enemies, while the mimic should not be protected by any distasteful qualities. The Müllerian theory, briefly stated, is that two or more species belonging to distasteful groups will derive benefit from mimetic resemblance because, although immune as compared with non-protected species, they are not altogether exempt from persecution, and the loss in individuals incurred by each mimetic species becomes proportionally more and more diminished the larger the number of indivduals over which the loss is distributed. Thus the resemblance being advantageous can be conceived to have been brought about by natural selection in the Müllerian mimicry in precisely the same way that it has been conceived to have been brought about in the Batesian mimicry. Whether it has actually been so brought about, is just the point about which there has been so much discussion; but if natural selection plays any part at all in species formation—and the writer still finds himself in the position of being without any other adequate theory—then a perusal of Prof. Poulton's paper, and the powerful arguments which he has marshalled therein, cannot fail to convince the unprejudiced naturalist that if natural selection was valid for Bates it is equally valid for Müller, and, further, that if natural selection is inadequate in either or both cases, then we have no theory of mimicry that will at all bear critical examination, and the whole body of facts remain as inexplicable as in pre-Darwinian times.

The method adopted by Prof. Poulton in the present paper is that of exclusion. He discusses all the alternative explanations which have been suggested, and finds them to be untenable when submitted to close analysis. There is thus left only the theory of natural selection The competing theories are all resolvable into three—viz. (1) external action of environment (2) independent development along similar lines by internal causes, and (3) psychical influence of predominating types of colour and pattern leading to the sexual selection of that type. The latter theory is not very likely to survive, although Mr. Darwin in 1872 wrote to the writer of this notice: "I do not feel at all sure that this view is as incredible as it may at first appear." It should be added that the said suggestion also came from Fritz Müller in a letter to Darwin. Rejecting for the present No. 3, the author deals at length with Nos. 1 and 2. Before marshalling the facts it is, however, considered necessary to insist that the resemblances herein dealt with are part and parcel of the general phenomenon of Protective Resemblance. This point is strangely put into the background, or altogether ignored, by the upholders of non-Darwinian theories of mimicry, and Prof. Poulton has done good service in bringing it well to the front again. It is surprising that the two sets of facts, viz. resemblance to environment and resemblance to other living species, should be dissociated, in spite of the circumstance that Bates and Wallace and most writers on the subject since have distinctly recognised the fundamental importance of grouping them together. It is, of course, inconvenient to the opponents of the Darwinian explanation to admit that resemblances to bark, leaves, twigs, &c., which are so well explained by natural selection, should be of the same order as a set of resemblances for which that explanation is regarded as indequate. And even if it is allowed that protective resemblance and the old (Batesian) mimicry are due to natural selection—as some of the speakers seemed to admit in the discussion of 1897—the extension to the newer (Müllerian) mimicry is opposed by either ignoring or denying the facts, or by substituting untenable theories.

The original theory of Müller was limited in its application to certain butterflies (*Ituna* and *Thyridia*) which were not very remote in their kinship, but in which the superficial resemblance was too exact to admit of explanation by blood-relationship alone. In 1882 the writer of this notice, in a paper published in the *Annals and Magazine of Natural History*, ventured upon an extension of the Müllerian principle to whole groups of related and "protected" species in which a general similarity in the type of pattern and colouring prevails. The idea was that the abstract type of marking became associated with a knowledge of inedibility in the mind of insectivorous enemies. Five years later (*Proc. Zool. Soc.*, 1887), the author of the paper now before us made a further advance by extending the Müllerian principle to large groups of insects quite unrelated by affinity, and belonging, in fact, to different orders. It is only necessary to bring together an assemblage of species belonging to different orders, and having a general superficial resemblance among themselves, to constitute a presumptive case of "Müllerian association." If it can be shown that this group of species is for one reason or another more or less exempt from persecution as compared with non-protected species, the case would at once become Müllerian as distinguished from Batesian. It is, of course, doubtful in many cases to which class a particular example of mimicry may belong. The result of the recent work of Poulton, Dixey and Mayer is to make it appear probable that the Müllerian principle is of more widespread importance in nature than the older principle of Bates.

Since the superficial resemblance of insects belonging to distinct orders, such as a moth to a wasp or beetle, a beetle to an ant, and so forth, cannot have been aided at the outset by blood-relationship, the result in all cases where the association is Müllerian, whether attributed to natural selection or to any other cause, can only have been brought about by a process of convergence. The essence of the Müllerian principle also is that the so-called protected species are subject to a certain percentage of extinction, and the resemblance which we now find among them is accordingly advantageous, in the same sense that a distasteful caterpillar is gorgeously coloured according to Wallace's well-known theory. For this reason Prof. Poulton prefers to limit the term mimicry to the Batesian principle; the Müllerian cases are described

in the present paper as "common warning colours, and the author proposes for them the term *synaposematic*.

Not the least satisfactory feature of the present summing up of the position by Prof. Poulton is the distinct convergence of the evidence in favour of the natural selection theory which has been accumulated since 1879. The sacrifice of a certain percentage of individuals to the inexperience of their enemies was an assumption on Müller's part, and the present writer well remembers pointing out in a letter to that eminent naturalist that his case would be enormously strengthened if he would make observations on the spot. The result was a long series of a distasteful *Acraea*, collected by Müller in order to show that bird-pecked wings were of frequent occurrence. Much evidence of the same kind has been since obtained, and a most valuable series of experiments conducted by Mr. Finn, in India, during the years 1895-96-97, and published in the *Journal* of the Asiatic Society of Bengal, have led that author to the conclusion that unpalatable forms are by no means altogether free from attack.

It must be further borne in mind that in 1879 the question of the non-transmission of acquired characters had not been brought into prominence. It was tacitly assumed in the theory of Bates that a knowledge of edible and inedible types could be transmitted by heredity. It is remarkable that Müller, by virtue of his hypothesis, should have unconsciously challenged this tacit assumption by suggesting that young birds had to learn by experience, and did not derive their knowledge of eatable and distasteful forms by heredity. The whole tendency of Prof. Lloyd Morgan's work of late years has been to confirm this suggestion by actual observation and experiment; and Mr. Finn, also, in summing up his results, states that "each bird has to separately acquire its experience, and well remembers what it has learned." Thus the Müllerian theory of 1879 has now been placed on a psychological basis of well-ascertained facts.

Those who still believe that common warning colours can be explained by internal or external causes, as defined in the present paper, will, we imagine, find the ground crumbling away from beneath their feet if they will seriously weigh the arguments set forth by Prof. Poulton. What series of external causes in nature are there, for example, which can so act upon an organism as to modify only those superficial characters which are required to bring about a resemblance to another form while leaving all other characters unmodified? To attribute such modification to independent evolution by virtue of innate tendencies or laws of growth or internal forces, appears to the writer to be substituting mysticism for scientific explanation. What external agencies can be conceived which shall, while acting without visible result upon the early stages of all kinds of insects, culminate only in a resemblance between the imagos? The external conditions of life are imposing themselves during the whole of the larval and pupal existence, and yet these forms remain quite distinct, while the imagos come forth at once with all their disguising characters perfected.

On considering again the undoubted fact that in many cases of mimicry and common warning colours the female only is affected, the inadequacy of any explanation depending on direct action of environment or internal evolutional "tendencies" becomes strikingly apparent. So also, as Prof. Poulton illustrates by a most remarkable set of examples, when insects of different orders resemble each other, the superficial similarity must necessarily be brought about by the most diverse kinds of modification of parts. To attribute such distinct and diverse modifications of form, directed towards a common end, to similarity of external forces or internal tendencies, seems to the writer to be a straining of hypothesis beyond any degree of rashness attributed to the supporters of natural selection. What natural agency can be imagined that will account for the production of a similar colour in two or more species—in one form by developing pigment, and in another by developing striation of surface, so as to produce the same chromatic effect, excepting selection which works only for advantageous results irrespective of means? Even within the same order, where the resemblances might be more reasonably supposed to be due to similarity of external conditions, the likeness is superficial only, and is brought about by the most diverse means. There is apparently no chemical relationship between pigments which produce the same visual effect in mimetic butterflies of different families. A visual resemblance is required only by natural selection; external and internal causes have been incompetent in such cases to modify the more deeply concerned physiological processes so as to produce similarity of appearance by identity of pigment. Such a character as transparency of wing, also, is shown to have been attained by several distinct methods; by reduction in the number of scales, by reduction in their size, by loss of pigment, by being set up on edge instead of lying flat, and so forth. Any common set of forces, external or internal, which can bring about the same result, viz. wing transparency, by such diverse methods is simply inconceivable.

We have given only a few illustrations of the arguments which the author makes use of in this paper to dispose of the theories which have been advanced by way of substitutes for natural selection. As Prof. Poulton says in conclusion: "The review of the whole subject during the past thirty-six years increases our confidence in the theories of Bates and Fritz Müller, while it disposes of all alternative hypotheses."

It should be added that many new examples of mimicry and common warning colours—some of them of the most striking character—are given in the paper. More particularly will English entomologists be interested in the resemblance of the young larvæ of *Stauropus fagi* to an ant, and of the similarity in appearance and habit of the young larvæ of *Endromis versicolor* to saw-fly larvæ.

R. MELDOLA.

PROFESSOR CHARLES FRIEDEL.

FRANCE has lost one of her most distinguished chemists in the person of Prof. Charles Friedel, member of the Institute, who died at Montauban on April 20. He was born in Strassburg on March 12, 1832. His father was a banker; his mother was the daughter of Dr. Duvernoy, well known in his day as a scientific man. He distinguished himself so greatly in his studies that he took his degree of Bachelor of Science with special honours. Desiring to follow science as his profession he went to Paris, and gained the special esteem of M. de Sénarmont, who caused him to be appointed conservator of the mineralogical collections at the École des Mines. He worked in the laboratory of the distinguished chemist M. Adolph Wurtz, also a native of Alsace, at the École de Médecine. In 1856 he married Miss Kœchlin, by whom he had five children, one of whom, George Friedel, is known as a professor at the mining school of St. Etienne. Mrs. Friedel died in 1871, at Vernex, where she had retired during the Franco-German war; and her husband, who was shut up in Paris, knew nothing of the sad event until after the city capitulated. He was married again, in 1873, to Mlle. Louise Combes, whose father was a member of the Institute of France, and who, with their son and a large circle of relations, now mourn his recent decease. To return to his professional distinctions: in 1869 he became Doctor of Science; two years after he received a high appointment at the École Normale Supérieure. In 1876 he became Professor of Mineralogy at the Faculté des Sciences, at the Sorbonne; and in 1878 he received the